GOLF PUTTING DISTANCE CONTROL TRAINING DEVICE

U.S. Patent Application of:

William Dean McConnell.

"Express mail" mailing label number
ER 389134137 US

Date of Deposit: 9/30/2003

I hereby certify that this correspondence, including the attachments listed on the accompanying New Utility Patent Application Transmittal, is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

William Dean McConnell

(Typed or printed name of person mailing paper or fee)

William Dean McConnell

(Signature of person mailing paper or fee)

Title of the Invention

GOLF PUTTING DISTANCE CONTROL TRAINING DEVICE.

Cross Reference to Related Applications

This application claims the benefit of provisional application serial number 60/418,943, filed on October 16, 2002.

Statement Regarding Federally Sponsored Research or Development

Not Applicable

Description of Attached Appendix

Not Applicable

Background of the Invention

This invention relates generally to golf training devices and more specifically to a golf putting training device that allows a golfer to practice putting a golf ball a precise distance in a very small area. In the game of golf, at least half of the strokes allocated to comprising the par for 18 holes are for putting. The putter is the club used most in a round of golf. Putting is the game within the game of golf that greatly affects the golfer's overall score. The most common problem associated with putting in a round of golf is the three-putt. After hitting an iron onto the green in regulation 25 feet from the hole, the golfer strokes the first putt either far short of the hole or far past the hole leaving a par putt of 6 feet or more. Most often, an average golfer will miss putts of more than 6

feet. Therefore, to eliminate three putts, a golfer must stroke the first putt 3 feet or closer from the hole to assure making the next putt. There are two components that comprise putting. They are distance and direction. Professional golf instructors know that in putting, distance is more important than direction. Therefore, average golfers can improve their putting ability by learning to hit long putts a precise distance ensuring that the remaining putt is a short tap-in. Practicing long putts is difficult due to many factors. It is sometimes difficult to find a practice green that is relatively flat for 20 feet or more. If the practice green is busy, it is difficult to find a path to a hole 20 feet or more that does not cross the path of another golfer practicing. Most golfers don't have the time to travel to a golf facility just to practice long putts. When they do go to the golf course for practice, they would rather hit drives and iron shots. A putting distance control training device that can be used indoors at home or in the office requiring only a very small space would allow a golfer to improve first putt distance control and thus improve overall scoring.

A variety of golf putting training devices have been developed to aid golfers in putting a golf ball a desired distance. For example, U.S. Pat. No. 5,788,583 discloses a system which predicts the distance that a golf ball will travel when struck by a putter head during a putting swing. The golfer swings the putter head over two optical sensors located a predetermined distance from each other. A timer generates a time difference value representing a difference between the time when the putter head travels over the first sensor and a second time when the putter head travels over the second sensor. A microprocessor determines the predicted distance by using the time difference measurement and green condition settings set by the golfer to fetch a predicted distance value from a lookup table predefined in memory. The golfer continues taking

practice strokes until the predicted distance matches the actual distance to the hole. This approach uses as its basis for golf ball distance estimation, the speed of the putter head during a practice stroke. In order to relate putter head speed to predicted golf ball distance, a lookup table is employed whose values are determined empirically through a data acquisition process. This process is performed by repeatedly placing a golf ball near the sensors, striking the ball with a putting stroke, recording the putter head time difference value, and then measuring and recording the actual distance that the ball rolled on the green. By repeating this process for several more practice strokes, the lookup table contents can be determined for a specific putt on a specific green. U.S. Pat. No. 5,788,583 requires a large amount of empirical data to be entered prior to using the device as a trainer and each data set entered covers one particular distance putt.

U.S. Pat. No. 6,146,283 discloses a system which assists golfers in practicing their respective putting stroke by indicating the distance a practice putt would have traveled upon a simulated green having a selected stimp value. The practice device employs a pair of putting targets mounted to a rotatable putting force sensor at opposite ends so as to counterbalance one another. The putting target is struck by a putter during a practice stroke resulting in the counterbalanced putting targets spinning along the axis of the stroke. The simulated speed of a golf ball is determined by relating the rotations per second of the putting force sensor to linear velocity. The linear velocity has a mass correction factor applied if the inertial mass of the counterbalanced putting targets differ significantly from that of a single golf ball. Finally, a microprocessor calculates the estimated distance based on the measured rotational speed and the stimp green speed selector setting.

U.S. Pat. No. 4,180,270 discloses a putting training apparatus which includes two retractable sensors flanking an imaginary golf ball. By swinging a putter at the imaginary ball, the first and second sensors are actuated and, based on which of the two sensors was actuated first, determines if the putter was open or closed at impact. The time difference in the two sensor actuations determines the direction accuracy of the golfer's putting stroke. A second embodiment of this patent employs a third and fourth sensor that actuate at a fixed distance from the two direction sensors. Using the time measured from the first two sensor actuations to the third and fourth sensor actuations, a distance estimate is made.

U.S. Pat. 5,788,583, U.S. Pat. 6,146,283, and U.S. Pat. 4,180,270 all predict the distance that a golf ball will roll. However, none in their basic mode of operation requires the striking and subsequent roll of a golf ball. Furthermore, none of the cited patents make direct speed measurements of a rolling golf ball during their use as training devices. Empirical data tables and mass correction factors are employed to model the predicted behavior of a golf ball struck by a putter.

U.S. Pat. No. 6,540,620 discloses a golf putter training device which aids a golfer in judging the speed of impact of a golf club head upon a ball. A golf ball is struck by a putter into an elongated structure equipped with a pair of optical sensors that measure the travel time of the golf ball as it passes from the first to the second sensor pair. The resulting count value is presented to a digital to analog converter whose output connects to a digital panel meter for display to the golfer. The number presented to the golfer is not a prediction of the golf ball roll distance but a relative indication of the force of impact so that the golfer can learn to repeat the same force stroke.

Brief Summary of the Invention

The primary object of the invention is to provide a golf putting training device which allows golfers to improve their putting distance control.

Another object of the invention is to provide a golf putting training device which accurately informs the golfer of the distance that the golf ball would have rolled on a green with a specified stimp value.

Another object of the invention is to provide a golf putting training device that is portable and allows a golfer to practice long putts in a small area very efficiently due to not having to retrieve the ball from a distance.

Yet another object of the invention is to provide a golf putting training device that allows a golfer to actually strike a golf ball and based on the rolling ball's direct measured speed, display the distance that the ball would have rolled on a green while also providing audio feedback as to the rolling time of the ball.

Other objects and advantages of the present invention will become apparent from the following descriptions, taken in connection with the accompanying drawings, wherein, by way of illustration and example, an embodiment of the present invention is disclosed.

In accordance with a preferred embodiment of the invention, there is disclosed a golf putting distance control training device comprising: a housing, a target strike plate backed with impact absorbing material mounted to the front side of the housing which serves as a putting target and receives the impact of a rolling golf ball, an impact detection sensor responsive to the collision of the rolling golf ball with the strike plate, circuitry for the amplification of the impact detection sensor signal and conversion to an impact sensor digital signal, a doppler microwave speed measurement sensor

responsive to the movement of the rolling golf ball by providing an audio signal output whose frequency is proportional to the speed of the ball, circuitry for the amplification of the doppler microwave speed measurement sensor signal and conversion to a digital signal, a green speed setting switch to allow the golfer to select the speed of the simulated green, a microcontroller to receive the doppler microwave speed measurement sensor digital signal, the impact sensor digital signal, and the green speed setting switch, and calculate and output an estimated ball roll distance to inform the golfer of the distance that the rolling golf ball would have traveled past the strike plate and an audible beeper to provide the golfer with an audible indication of the progress of the simulated rolling ball.

Brief Description of the Drawings

The drawings constitute a part of this specification and include exemplary embodiments to the invention, which may be embodied in various forms.

Figure 1 is a perspective view of the putting distance control trainer device.

Figure 2 is a perspective view of the putting distance control trainer device showing the interior mounted dopper microwave speed sensor, audible beeper, impact detection microphone sensor, and printed circuit board parts in broken lines.

Figure 3 is a side elevation of the putting distance control trainer device showing the strike plate, impact absorbing material layer, bumpers, and rear stabilizing plate.

Figure 4 is a rear perspective view of the putting distance control trainer device showing the rear stabilizing plate and bumpers.

Figure 5 is a schematic block diagram of the major electronic elements of the putting distance control trainer device.

Figure 6 is an electrical schematic of the doppler microwave speed sensor, preamplifier, and schmitt trigger output signal.

Figure 7 is an electrical schematic of the microphone impact detection sensor, preamplifier, and schmitt trigger output signal.

Figure 8 is a flow chart of the operations that comprise the main background microcontroller software processing.

Figure 9 is a flow chart of the operations that comprise the microcontroller software processing of the doppler microwave speed sensor interrupt service routine.

Figure 10 is a flow chart of the operations that comprise the microcontroller software processing of the microphone impact sensor interrupt service routine.

Figure 11 is a perspective view of an alternate embodiment of the putting distance control trainer device showing the interior mounted dopper microwave speed sensor, impact detection microphone sensor, and printed circuit board parts in broken lines.

Figure 12 is a schematic block diagram of the major electronic elements comprising an alternate embodiment of the putting distance control trainer device.

Figure 13 is a flow chart of the operations that comprise the main background microcontroller software processing for an alternate embodiment of the putting distance control trainer device.

Detailed Description of the Preferred Embodiments

Detailed descriptions of the preferred embodiment are provided herein. It is to be understood, however, that the present invention may be embodied in various forms. Therefore, specific details disclosed herein are not to be interpreted as limiting, but rather as a basis for the claims and as a representative basis for teaching one skilled in the art to employ the present invention in virtually any appropriately detailed system, structure or manner.

Referring to the drawings, a golf putting training device is indicated generally in FIG. **1**. As indicated in FIG. **1**, a golfer (not shown) strokes golf ball **50** with putter **52** approximately two feet from golf putting distance control training device housing **20** in the direction of the center of target strike plate **22**. Golf ball **50** and housing **20** are preferably placed on carpeted floor comprised of short fibers to provide a fast true roll. Impact absorbing foam material **24** is located behind target strike plate **22** in order to reduce the subsequent collision recoil. Housing **20** preferably is weighted with a material that is heavy enough to provide positional stabilization during impact of rolling golf ball **50** with strike plate **22**. Rear stabilization plate **30** further aids in positional stabilization. In this embodiment, a steel plate (not shown) mounted to the interior back side of housing **20** provides sufficient weight to hold the housing in place during impact. However, the construction material is not limited to steel. Bumpers **32** attached to the bottom of housing **20** and rear stabilization plate **30** hold housing **20** in place during ball impact (back left bumper not shown). Green speed setting dipswitch **28** selects the green speed and display **26** communicates the estimated ball roll distance in feet to the golfer. As shown in FIG. **2**, doppler microwave speed sensor **34**, microphone impact detection sensor **36**, and audible beeper **54** are located inside housing **20** mounted onto

printed circuit board **38.** The preferred material for housing **20** is plastic to allow for doppler microwave speed sensor **34** to propagate a transmit signal toward rolling golf ball **50** and receive a doppler-shifted return signal from rolling golf ball **50** through housing **20**. After impact of rolling golf ball **50** with target strike plate **22**, the distance that the golf ball would have traveled past strike plate **22** is communicated to the golfer on display **26**. In this embodiment, display **26** is a two digit 7-segment display. It will be understood by those skilled in the art that other golfer communication means, such as a Liquid Crystal Display or an audible speech integrated circuit, or a personal computer interfaced through a serial interface could be used in place of the 7-segment display to communicate the estimated ball roll distance to the golfer. Using the putting distance control trainer device repeatedly, the golfer can learn to putt a ball for example, 15, 25, or 45 feet in length consistently. Referring to FIG. **3** and FIG. **4**, rear stabilization plate **30** is mounted to the back side of housing **20** approximately one half inch from the bottom which results in a housing upward tilt of approximately 7 degrees when the golf putting distance control trainer device is placed on the floor. The upward tilt reduces ball recoil at impact and also aids in golfer viewing of display **26** (shown in FIG. **2**). A total of four bumpers **32** are mounted to the bottom of housing **20** and rear stabilization plate **30** which provide a high frictional contact with the floor.

The golf putting training device is comprised of the major electronic elements shown in FIG. **5**. These include doppler microwave speed sensor **34** and associated preamplifier **40** and schmitt trigger **42**, microphone impact sensor **36** and associated preamplifier **44** and schmitt trigger **46**, microcontroller **48**, green speed setting switch **28**, display **26** for communicating distance information to the golfer, and audible beeper **54** for communicating simulated ball roll progress to the golfer. The output of schmitt

trigger **42** is the INT0 **43** digital signal that interrupts microcontroller **48**. The output of schmitt trigger **46** is the INT1 **47** digital signal that interrupts microcontroller **48** when an impact of golf ball **50** (shown in FIG. **1**) with target strike plate **22** (also shown in FIG. **1**) occurs.

The putting distance control trainer device includes doppler microwave speed sensor **34** for providing a direct indication of the speed of the golf ball as it travels towards target strike plate **22** (shown in FIG. **2**). Accordingly, doppler microwave speed sensor **34** comprises a commercially available doppler microwave speed sensor responsive to the movement of an object such as a rolling golf ball. Doppler microwave speed sensor **34** outputs an audio-band signal whose frequency is proportional to the speed of the object in its beam. A specific scale factor of cycles per second per feet per second is associated with the particular frequency band of the device. For the particular X-band device used in this embodiment, the scale factor is 21.4 Hz per feet per second. Doppler microwave speed sensor **34**, is followed by signal amplification preamplifier **40**. As shown in FIG. **6**, the output of doppler microwave speed sensor **34** is capacitive coupled through C1 to input resistor R1 of the first stage of an operational amplifier such as a commercially available National Semiconductor LM1458. The amplifier, used in an inverting configuration, includes feedback resistor R2 and high frequency roll off capacitor C2. A bias voltage level is applied to the non-inverting input of the amplifier through a voltage divider network formed from R3 and R4 to set the output voltage to 2.5 volts. The output of the first stage amplifier is capacitor coupled through C3 to the second stage amplifier through input resistor R5. The second stage amplifier is also biased at the non-inverting input by the voltage divider network to 2.5 volts. The second stage amplifier includes feedback resistor R6 and high frequency roll off capacitor C4.

The output of the second stage amplifier is direct coupled to the input of schmitt trigger **42**. Schmitt trigger **42** provides a conversion from an analog signal to a digital signal, INT0 **43**. The digital output signal of the schmitt trigger is connected to the INT0 input of microcontroller **48** (shown in FIG. **5**). When the INT0 signal **43** transitions from a digital high state to a digital low state, microcontroller **48** (shown in FIG. **5**) software program is interrupted and program control is switched to a microwave speed sensor interrupt service routine. After the completion of the execution of microwave speed sensor interrupt service routine, control of the program returns to the location that was executing prior to the interrupt occurrence.

Referring to FIG. **6,** a voltage regulator converts conventional 110VAC to +9VDC DC power supply module (not shown) +9V output power to +5V used by the putting distance control trainer device electronic circuitry.

Referring to FIG. **2** and FIG. **3**, target strike plate **22** provides an impact noise when struck by rolling golf ball **50**. Located between target strike plate **22** and housing **20** is a layer of impact absorbing material **24** which absorbs the impact of the ball with target strike plate **22** and reduces ball recoil. Impact detection microphone sensor **36** is mounted on printed circuit board **38** within housing **20**. Referring to FIG. **7**, microphone impact sensor **36** is biased through resistor R7 to +5V, and is capacitive coupled through C5 to the inverting input of a commercially available National Semiconductor LM741 operational amplifier through resistor R8. The amplifier includes a feedback resistor R9. A bias voltage level formed by R10 and R11 is applied to the non inverting input of the amplifier. The output of the amplifier is direct coupled to the input of schmitt trigger **46**. The schmitt trigger **46** converts the analog microphone signal to the INT1 **47** digital signal which is presented to the INT1 interrupt of microcontroller **48** (shown in

FIG. **5**). When an impact of rolling golf ball **50** (shown in FIG. **2**) occurs with target strike plate **22** (shown in FIG. **2**), a digital pulse appears at the INT1 interrupt pin of microcontroller **48** (shown in FIG. **5**). When the INT1 signal transitions from a digital high to a digital low state, microcontroller **48** (shown in FIG. **5**) software program is interrupted and program control is switched to a microphone impact interrupt service routine **116** (shown in FIG. **10**). After the completion of the execution of microphone impact interrupt service routine **116** (shown in FIG. **10**), control of the program returns, in step **120** of Fig. **10**, back to the location that was executing prior to the interrupt occurrence.

Referring to FIG. **2**, display **26** communicates the estimated rolling golf ball travel distance information in feet to the golfer. Green speed setting **28** switch determines the speed of the green that will be simulated in the calculation of distance, and is comprised of a three position dipswitch mounted on printed circuit board **38** and accessible through a cutout area in the front of housing **20.** The green speed setting allows the golfer to simulate greens from a stimp value of 5.0 to a stimp value of 12.0 in 1.0 stimp value increments. Knowing the approximate speed of the greens that the golfer will putt on an upcoming round allows the golfer to practice under similar circumstances with the putting distance control trainer.

Referring to FIG. **5**, microcontroller **48** coordinates the putting distance control trainer distance estimation process and presents the ball roll distance to the golfer for viewing on display **26**. Microcontroller **48** is programmed to perform control and coordination of signal interrupts, timing, mathmatical calculations, display of the distance information, and audible output of ball roll progress to beeper **54**. Three inputs to microcontroller **48** provide the information necessary to calculate the roll distance

estimate. These include the microwave speed sensor interrupt INT0 **43**, the microphone impact signal interrupt INT1 **47**, and the green speed setting switch **28**.

Referring to FIG. **8**, microcontroller software background software **100** starts from power up and in step **102** reads green speed setting dipswitch **28** (shown in FIG. **5**), flashes green speed setting on display **26** (shown in FIG. **5**) three times and then clears the display to 0 feet. The software variable, IMPACT_FLAG, is cleared to FALSE and microwave speed sensor signal software interrupt and microphone impact detection software interrupts are enabled in step **104**. Microcontroller software background software **100**) continuously checks IMPACT_FLAG for a TRUE condition in step **106**. IMPACT_FLAG can only be set TRUE by the microphone impact interrupt service routine **116** (shown in FIG. **10**). While microcontroller software background software is checking IMPACT_FLAG for a TRUE condition in step **106** (shown in FIG. **8**), microwave speed sensor interrupt service routine step **110** (shown in FIG. **9**) is executed in response to movement of an object in the path of doppler microwave speed sensor **34** (shown in FIG. **5**). When microwave speed sensor interrupt INT0 **43**, (shown in FIG. **5**), coupled to the microcontroller INT0 input transitions from high to low, it forces the microcontroller software program to stop current background processing and branch to a software routine specifically written for the INT0 event. Refer to FIG. **9**. Microwave speed sensor interrupt service routine software **110** is called in response to the INT0 interrupt. Microwave speed sensor interrupt service routine **110** stores a measured timestamp value into the next location of length n circular speed sensor buffer. The circular memory buffer allows continuous storage of values in a fixed size memory structure such that older values are overwritten with newer ones. In this embodiment, length n is 16, but is not limited to 16. Software variables used in

microwave speed sensor interrupt service routine **110** include ELAPSED_TIME, CURRENT_TIME, and PREVIOUS_TIME. These variables are used in the determination of each period of the doppler microwave speed sensor digital signal that is stored in the next speed sensor buffer location. As shown in step **112**, the variable PREVIOUS_TIME is set equal to the value stored in CURRENT_TIME. The contents of CURRENT_TIME represents the microcontroller timer value captured during the previous microwave speed sensor interrupt service routine. The variable, CURRENT_TIME, is then set equal to the current timer value. The time between the previous interrupt and the current interrupt is therefore (CURRENT_TIME - PREVIOUS_TIME). This difference value is stored into the variable ELAPSED_TIME and represents the time in microseconds of the most current period of the microwave speed sensor digital signal. Thus, the ELAPSED_TIME timestamps stored in the speed sensor buffer are the periods of each cycle of the microwave speed sensor digital signal representing the movement of rolling golf ball **50** (shown in FIG. **2**) on its path to target strike plate **22** (shown in FIG. **2**). Microcontroller software in step **112** stores timestamp information into the speed sensor buffer for a cycle, then returns from microwave speed sensor interrupt service routine in step **114** to background software step **106** (shown in FIG. **8**). The storage of timestamp data continues indefinitely until a golf ball impact event occurs. Referring to FIG. **2**, when impact of rolling golf ball **50** with strike plate **22** occurs, an impact sound is generated which microphone impact sensor **36** senses. Referring to FIG. **5**, output signal from microphone impact sensor **36** is amplified and converted to a digital signal that causes an INT1 interrupt of microcontroller **48**. Microphone impact detection interrupt service routine **116** (shown in FIG. **10**) is called in response to microcontroller **48** (shown in FIG. **5**) receiving an INT1 **47** (shown in FIG. **5**)

high to low transition when rolling golf ball **50** (shown in FIG. **2**) impacts target strike plate **22** (shown in FIG. **2**). Microphone impact detection interrupt service routine **116** (shown in FIG. **10**) sets IMPACT_FLAG to TRUE, and disables all microphone impact sensor interrupts and microwave speed sensor interrupts as shown in step **118**. Control is returned to microcontroller software background processing as shown in step **120**. Referring to FIG. **8**, step **106** detects IMPACT_FLAG being set to TRUE by microphone impact detection interrupt service routine and begins the calculation of the distance estimate in step **108**. The distance estimation microcontroller software first determines the speed of the ball as it impacted target strike plate **22** (shown in FIG. **2**). This is done by starting at the last stored timestamp location in the length n circular buffer and working backward in time to access the last n/2 timestamps. The last n/2 timestamps are then sorted from shortest to longest period length. The second and third shortest timestamps, which represent the fastest two valid single cycle speeds, are averaged to represent the composite period of the microwave speed sensor digital signal at impact. The reciprocal of this value is the frequency in cycles per second of the microwave speed sensor digital signal at impact. Transforming this quantity to a feet per second quantity requires application of a scaling factor associated with the specific microwave sensor used. For the X-band device used in the preferred embodiment, the scale factor is 21.4 Hz per feet per second. Using scale factor 21.4 Hz/ft/sec, the speed of the ball just prior to impact is (1/composite period)/21.4 Hz/ft/sec

Applying Newton's second law f = ma, the distance a ball travels with initial velocity v over a surface with coefficient of friction μ is $(v^2) / (2g\mu)$, where g is the gravitational acceleration constant (approximately 32.19 ft/sec^2). Knowing the velocity v, and the coefficient of friction μ, the distance can be determined. However, in order to

calculate the distance based on a stimp value, the stimp number must first be related to the coefficient of friction.

The stimpmeter is a device that is basically a 36 inch long metal bar with a V-shaped trough which is slowly raised to an angle of 20 degrees. A golf ball is placed in a notch 6 inches from the raised end. The ball releases from the notch when the stimpmeter is raised to 20 degrees. The ball then rolls down the inclined plane until it reaches the surface of the green. The distance in feet that the ball rolls from the bottom of the stimpmeter to where it stops on the green is the stimp value for the green. The area chosen for the measurement must be relatively flat and an average of three rolls is taken provided the three balls fall within a maximum deviation criteria. The length of the incline is 30 inches or 2.5 feet. The height of the ball where it releases is 2.5 feet * sin(20 degrees) or 0.855 feet.

A ball of mass m, and height h on an incline has initial potential energy of mgh, where g is the gravatational constant. At the top of the incline, just prior to release, the ball has zero rotational kinetic energy and zero regular kinetic energy. At the bottom of the inclined plane, the ball has zero potential energy, $(1/2)mv^2$ regular kinetic energy and $(1/2)I\omega^2$ rotational kinetic energy where I is the centroidal moment of inertia of the rolling object.and ω is angular velocity. Using conservation of energy, which states that the total initial energy of the ball at the top of the incline equals the total energy at the bottom of the incline, the following equation applies: $mgh = (1/2)mv^2 + (1/2)I\omega^2$.

The centroidal moment of inertia for a uniform spherical object is $(2/5)mr^2$ where r is the radius of the sphere. Also, relating the angular velocity ω to linear velocity, $\omega = v/r$. Substituting $I = (2/5)mr^2$ and $\omega = v/r$ gives: $mgh = (1/2)mv^2 + (1/2)[(2/5)mr^2][v^2/r^2]$

or mgh = $(1/2)mv^2 + (1/5)mv^2 = (7/10)mv^2$. Solving for v: $v = [(10/7)gh]^{1/2} = [(10/7)*32.2ft/sec^{2}*.855ft]^{1/2} = 6.27$ ft/sec.

Therefore, a ball will roll at a speed of 6.27 ft/sec emerging from the bottom of a stimpmeter raised to an angle of 20 degrees. Solving for μ in the equation Distance = $v2/(2g\mu)$, $\mu = v^2/(\text{Distance}*2*g)$. For a roll distance of 1 foot on a green whose stimp value is 1.0, the coefficient of friction would be: $\mu = (6.27ft/sec)^2/(1\ ft*2*32.2\ ft/sec^2) = .611$. Therefore, the stimp value, stimp, is related to the coefficient of friction by the factor: $\mu = .611/\text{stimp}$. The coefficient of friction μ, is equal to 0.611 divided by the stimp value. Replacing μ with .611/stimp, the following equation relates rolling distance to initial ball speed: Distance = $(v^2*\text{stimp})/(64.38*.611)$ or $(v^2*\text{stimp})/39.31$.

Therefore, given an initial ball speed as measured by doppler microwave speed sensor **34** (shown in FIG. **5**) and based on the selected green speed setting **28** (shown in FIG. **5**) in stimp units, the estimated roll distance can be calculated and displayed. For instance, if the speed of the ball were measured at 12.54 ft/sec for a stimp value of 10, the distance rolled would be $(12.54ft/sec^2)*(10)/39.31 = 40$ feet. After the distance calculation rounded up to the nearest foot has been completed, it is output to the two digit display.

As shown in FIG. **2**, beeper **54** provides an audio indication of the simulated roll duration of golf ball **50** past impact with strike plate **22**. As shown in FIG. **5**, microcontroller **48** controls beeper **54**. As shown in step **109** (shown in FIG. **8**), an audible beep is output to the golfer after the distance has been calculated and displayed, for every quarter turn of the simulated roll of the golf ball until the golf ball stops. In this embodiment, the ball roll progress increment is a quarter turn, however any increment could be chosen such as 1 full turn, a half turn, or one eighth of a turn.

The diameter of a standard golf ball is 1.68 inches. The circumference of a golf ball is πd, where d is the diameter. A quarter turn of a golf ball is therefore $((\pi 1.68 \text{ in})/4)/12\text{in./ft.} = 0.11$ feet. Knowing the total distance that the golf ball will roll, d_{TOTAL}, the initial speed of the rolling golf ball, v_o, the coefficient of friction in terms of the Stimp value, .611/stimp, and the linear length of a quarter turn of a standard golf ball, 0.11 feet, the time duration of each quarter turn of the rolling golf ball can be calculated. The following equation relates the distance rolled to the initial velocity, the acceleration of the golf ball, and the time. $s = s_o + v_o t + (1/2)at^2$ where s_o is the initial position of the ball, v_o is the initial ball speed, t is the time to reach distance s, and a is the acceleration. The uniform acceleration of a rolling golf ball due to the frictional force of the green is: $a = - v_o^2/(2d_{TOTAL})$. Substituting $a = - v_o^2/(2d_{TOTAL})$ into $s = s_o + v_o t + (1/2)at^2$, $s = s_o + v_o t - (v_o^2/(4d_{TOTAL}))t^2$ or, re-arranging, $- (v_o^2/(4d_{TOTAL}))t^2 + v_o t - s + s_o = 0$. Recognizing that the derived equation is quadratic, the solution to a quadratic equation of the form $ax^2 + bx + c = 0$ is: $x = (-b \pm (b^2 - 4ac)^{1/2})/2a$. Applying the quadratic solution equation to solve for time t, the time t to roll distance s is $t = (-v_o + (v_o^2 - sv_o^2/d_{TOTAL})^{1/2})/(- v_o^2/(2d_{TOTAL}))$. Using this equation, the time between each distance increment of 0.11 feet is calculated. The timer in the microcontroller is set for each quarter turn roll duration estimated time. At the end of each timeout, the microcontroller software outputs a short pulse burst to the beeper which creates an audible beep. Referring to FIG. **2**, after rolling golf ball **50** impacts strike plate **22**, the path of the simulated golf ball then begins to roll past strike plate **22** and the golfer is provided with aural feedback as to the progress of the simulated rolling ball's progress. As the simulated ball rolls, the time between quarter turn beeps gets longer until the ball finally stops and the beeps cease. The aural beeps thus provide the golfer with a feel

for the distance that the ball would have traveled in addition to the visual numeric distance display. One skilled in the art will recognize other ways of communicating the simulated golf ball's rolling progress to the golfer such as a flashing LED or a graphical depiction of a rolling golf ball on a personal computer screen. After the distance has been displayed and an audible beep has been output for every quarter turn of the simulated roll of the golf ball, all memory variables are reset and interrupts INT0 and INT1 are re-enabled to begin another distance estimation process after the next putt.

Referring to FIG. **11**, an alternate embodiment of the putting distance control training device is shown. In this embodiment, the distance control training device estimates the impact speed of the rolling golf ball and transmits the speed over a serial port to a peripheral computing device which calculates and displays the estimated ball roll distance. Alternate embodiment includes housing **20'**, bumpers **32'**, target strike plate **22'**, impact absorbing material **24'**, doppler microwave speed sensor **34'**, microphone impact detection sensor **36'**, printed circuit board **38'**, and peripheral serial interface port **56**. The major electronic elements for the alternate embodiment as shown in FIG. **12** include doppler microwave speed sensor **34'** and associated preamplifier **40'** and schmitt trigger **42'**, microphone impact sensor **36'** and associated preamplifier **44'** and schmitt trigger **46'**, microcontroller **48'**, peripheral serial interface signal **56**, and peripheral computing device **58**. The output of schmitt trigger **42'** is the INT0 **43'** digital signal that interrupts microcontroller **48'**. The output of schmitt trigger **46'** is the INT1 **47'** digital signal that interrupts microcontroller **48'** when an impact of golf ball **50'** (shown in FIG. **11**) with the target strike plate **22'** (shown in FIG. **11**) occurs. Referring to FIG. **13**, main background software processing **100'** clears IMPACT_FLAG to FALSE and enables both the speed sensor and impact detection sensor interrupts in step **104'**.

In step **106'**, IMPACT_FLAG is checked for a TRUE condition. Upon impact of the rolling golf ball with the target strike plate, IMPACT_FLAG is set to TRUE by microphone impact interrupt service routine. When step **106'** detects IMPACT_FLAG has been set to TRUE, step **108'** is performed. In step **108'**, the most recent n/2 speed sensor buffer timestamps are sorted from shortest to longest period. The second and third shortest periods are averaged to form the composite period of the microwave speed sensor digital signal at impact. The reciprocal of this value is the frequency in cycles per second of the microwave speed sensor digital signal at impact. Transforming this quantity to a feet per second quantity requires application of a scaling factor associated with the specific microwave sensor used. As mentioned previously in the preferred embodiment, the scale factor of the X-band sensor is 21.4 Hz per feet per second. Using scale factor 21.4 Hz/ft/sec, the speed of the ball just prior to impact is (1/composite period)/21.4 Hz/ft/sec. The ball impact speed is then output over peripheral serial interface port **56** (shown in FIG. **12**) to peripheral computing device **58** (also shown in FIG. **12**). Peripheral computing device **58** in this alternate embodiment is a conventional personal computer, personal digital assistant, or video game platform equipped with a serial port or universal serial bus interface. Peripheral computing device **58** receives the ball impact speed, calculates a simulated ball rolling distance using the equation Distance = $(v^2 * stimp)/39.31$, and outputs the distance to its display. The simulated green speed setting and the configuration of the simulated green are selectable on peripheral computing device **58**. Various simulated green configurations are selectable from the peripheral computing device **58**.

In View of the foregoing, it will be seen that the object of the invention is achieved. As various changes could be made in the above construction and methods without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

While the invention has been described in connection with a preferred embodiment, it is not intended to limit the scope of the invention to the particular form set forth, but on the contrary, it is intended to cover such alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.